cent. of coal gas respectively: the height of the cap being noted in each mixture when the hydrogen flame was first 10 mm., and then 15 mm., in height.

| | Flame 10 mm. | Flame 15 mm. |
|---|---|---|
| 1 per cent. gas .... | 27 mm. cap ..... | 50 mm. cap. |
| $0\frac{1}{2}$ „ .... | 23 „ ..... | 38 „ |

Attention is directed in the above statement to the *height* of the cap alone, but, as a matter of fact, its change in general appearance is also very noticeable as the proportion of gas is increased. Very careful observation of the hydrogen flame in air free from gas serves to detect a slender and very pale cap. When the gas in the air reaches 0·25 per cent. the cap becomes broader and pale grey in colour, but is still indefinite in outline, especially at its summit, and is seen only *above* the hydrogen flame. As the proportion of gas increases, the flame becomes strikingly sharp and pointed in outline, distinctly bluish-grey in colour, and gradually broadens and extends down the sides of the hydrogen flame, finally enclosing it altogether and encircling the jet. At the same time, the hydrogen flame itself is constantly growing in every dimension, gaining in luminosity and acquiring a rose-red tip. It is well to have watched the above changes in the test-chamber, and to have become familiar with the appearance of the hydrogen flame in different percentages of gas before the flame is used for gas-testing.

The use of the hydrogen flame for gas-testing has the advantage of rendering possible the employment of a non-luminous flame which can be immediately adjusted to any convenient size: not only may the size of the cap be thus increased at will by enlarging the flame, but it is possible to avoid the risk of losing the flame in the lamp, which is incurred by drawing down the wick very low when an oil flame is made use of for gas-testing.

## III. "On the Application of the Safety-lamp to the Detection of Benzoline Vapour and other Inflammable Vapours in the Air." By Frank Clowes, D.Sc. (Lond.), Professor of Chemistry, University College, Nottingham. Communicated by Professor Armstrong, F.R.S. Received March 24, 1892.

Since the vapour of benzoline and of petroleum spirit, when mixed with air, may become dangerously explosive and inflammable, it is found necessary to employ safety-lamps instead of naked lights to illuminate spaces which may contain such a mixture. The safety-lamp should accordingly be used in the neighbourhood of the oil

tanks in petroleum-carrying steamers, in petroleum stores, and in chambers in which processes are carried on which involve the use of light petroleum oil.

The suggestion naturally occurs, that the safety-lamps used in these places should be applied to ascertain whether the amount of inflammable vapour present in the air is sufficient to give rise to danger if it should come into contact with a naked flame; in other words, to ascertain if the space is efficiently ventilated. Experiments were accordingly undertaken to discover whether benzoline vapour would give rise to a "cap" over the flame of the safety-lamp, and if a "cap" appeared, to discover how small a proportion of the vapour could be detected in air by this flame-cap test. Since the hydrogen flame in the safety-lamp, and the benzoline flame in Ashworth's modified lamp, had been found to be most convenient for the formation of visible "caps," these lamps were employed in the experiments; and the test-chamber above described was employed for exposing the lamps to mixtures in varying proportions of benzoline vapour with air.

Since benzoline is a mixture of liquids, and is therefore not of invariable chemical composition, no attempt was made to ascertain the actual percentage of the vapour present in the air. The percentages of vapour, even if known and identical in amount, would probably have different effects when derived from different samples of benzoline, or even when derived from the same samples under different conditions. Accordingly an approximate determination only was made of the amount of further dilution with air, which an explosive or inflammable mixture might undergo, before the "cap" it produced over the safety-lamp flame ceased to be easily visible.

A large gas-holder was filled with air which had bubbled through benzoline, and was thus charged with the vapour at the ordinary temperature, in the same way as air would be charged with the vapour from the evaporation of stored benzoline. This mixture was inflammable when kindled in the open air. Varying proportions of this mixture with additional air were then prepared, and the effect was ascertained of introducing a flame into them. It was found that a mixture of 1 volume of the benzolised air with 4 volumes of air was violently explosive. When the proportion of air was increased from 4 to 7 volumes the mixture was still inflammable, and when the air was increased to 9 volumes the mixture ceased to be inflammable. Mixtures of the same benzolised air were then made in the test-chamber (pp. 87—90) with still larger proportions of air, and the appearance of the safety-lamp flames was examined in these mixtures, with the following results:—

| Proportion of benzolised air to air in mixture. | Behaviour of the mixture with a naked flame. | Height of the "cap" over the hydrogen safety-lamp flame in the mixture. |
|---|---|---|
| 1 : 4 | Violently explosive. | |
| 1 : 5 | Burns rapidly, and would probably be explosive if fired in large quantity. | |
| 1 : 6 | | |
| 1 : 7 | | |
| 1 : 8 | Burns around a flame only. | |
| 1 : 9 | Non-inflammable. | |
| 1 : 23 | ,, | 52 mm. "cap." |
| 1 : 36 | ,, | 43 ,, ,,<br>(4 ,, ,, with benzoline flame.) |
| 1 : 72 | ,, | 31 mm. "cap." |
| 1 : 144 | ,, | 22 ,, ,, |

The results of these experiments showed that the 10 mm. hydrogen flame in the Ashworth safety-lamp will detect a quantity of benzoline vapour in air which is only 1/36th that of the explosive proportion, and 1/20th of that which is inflammable when mixed with air. The benzoline flame shows a very small but distinct "cap" when the amount of benzoline vapour is 1/9th that requisite for the production of an explosive mixture, and 1/5th that which will yield an inflammable mixture.

Further experiments of a similar kind are being made with the vapour of alcohol and of ether.

I have to acknowledge with pleasure the valuable manipulative skill and fertility of resource of W. T. Rigby, who has assisted me in carrying out the experiments with the test-chamber.